THERMALS AND BUTTERFLY (LEPIDOPTERA) MIGRATIONS FROM AUSTRALIA TO NEW ZEALAND

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Abstract

Two direct observations of butterflies at high altitudes in thermals are noted, supporting the hypothesis that long distance migration of butterflies between Australia and New Zealand takes place at high altitudes.

Introduction

The arrival of Australian insects in New Zealand from across the Tasman Sea is a well known phenomenon. Perusal of papers such as those of Ramsay (1954, 1971), Ramsay and Ordish (1966), Gibbs (1969), Fox (1978) and Early *et al.* (1995), plus references provided by these authors, give details and discussion of many such arrivals, especially of butterflies. Holloway (1977, 1996) discussed in great detail similar arrivals on Norfolk Island (especially of moths), based on a remarkable long-term light-trapping program carried out by Marge and Fred Jowett. Observations have been recorded of the arrival of the butterflies *Vanessa kershawi* (McCoy) on Norfolk Island (Smithers 1969), *Belenois java teutonia* (Fabricius) on Lord Howe Island (Smithers 1970) and *Tirumala hamata* (W.S. Macleay) on Norfolk Island (Smithers 1995). Tomlinson (1973) discussed meteorological aspects of dispersal of insects across the Tasman Sea and Holloway (1977) discussed possible mechanisms of transport of insects to Norfolk Island. Further afield, recent work on *Danaus plexippus* (Linnaeus) in North America (Calvert 2001) and *Vanessa cardui* (Linnaeus) migrating from North Africa to Europe (Stefanescu *et al*. 2007), has convincingly demonstrated the use of thermals and high altitude synoptic scale winds to assist migration.

Opinions on long-distance butterfly migration over water

There has been some uncertainty, if not reluctance, as to acceptance of the possibility of butterflies undertaking long-distance flights over water from Australia to New Zealand in low temperature, fast-moving, high altitude air streams. There appears to have been greater acceptance that the journey could be made at low levels with wind assistance. Wind assistance is regarded as essential by most authors, because 'refuelling' by nectar intake is not possible over the sea and because of the physiological inability of the insects to fly for the time needed to make the crossing without such help. Johnson (1969) discussed the physiological needs of insects undertaking long-distance flights and suggested that rapid high altitude flight was involved for some of them. Ramsay (1954) pointed out that, during ten days before the recorded arrival of specimens of *Junonia villida* (Fabricius) in New Zealand, 'there were at least three occasions on which these insects could have been carried across the Tasman Sea', implying that they were blown from Australia. The time taken for such a journey was given as 'about 3 days'. Ramsay and Ordish

(1966) discussed weather conditions in relation to an extensive influx of *Hypolimnas bolina nerina* (Fabricius) in 1956, in terms which suggest that the major factor enabling butterflies to make the journey was the wind. They also estimated that 'The time of transit for a *non-active* butterfly being *carried* [my italics in both cases] from the Australian coast near Sydney to New Zealand would have varied between one and four days ...' and noted that 'Many of the butterflies arrived in remarkably good condition and therefore must have had a relatively easy passage.' We find also a suggestion that 'At 10,000 ft, where the wind direction was much more constant, the speed varied between 20 and 50 knots, but mostly remained at near 30 knots. Strong WNW winds occurred near ground level in the Sydney-Newcastle area from 15-18 April and may have carried the butterflies up and out into the trans-Tasman airflow.' The interesting suggestion that winds at higher altitudes might be involved is not followed up, probably because of lack of direct evidence or disbelief that they could survive for long enough at the low temperatures and high altitudes. 'After 20 April the winds became southerly ... Thus, there was less chance of the butterflies being *carried* [my italics] to New Zealand in this manner after 20 April, the period when most butterflies were seen.' Gibbs (1969) recorded an immigration of large numbers of *Vanessa kershawi* in New Zealand in October/November 1968, at the same time as this species was arriving on Norfolk Island (Smithers 1969). Gibbs suggested, on the basis of smoke arriving from bushfires near Sydney, that 'winds at the time of the main 1968 invasions were favourable for the movement of butterflies'.

Smithers (1969), when recording the arrival of what was obviously part of the same migrant population of *V. kershawi* on Norfolk Island, also with smoke from Australian fires, pointed out that the 'air conditions in many parts of eastern Australia were such that strong updraughts from extensive bushfires were common. Over wide areas, therefore, conditions were favourable for the rapid lifting of specimens in flight to heights of 15,000 feet and more. At these heights, winds were easily capable of transporting specimens to Norfolk Island and the passive movement of torpid butterflies could have been quite rapid; certainly a short enough period of time would be involved to permit butterflies to descend unharmed.' It is a frequently observed fact that partly burned leaves and other debris are lifted high during a bushfire and carried a long distance before returning to earth. Clearly, a butterfly raised to high altitudes, where temperatures low enough to induce torpor are encountered, could be carried at the high speeds of high altitude winds for considerable distances before descending to warmer air. The fact that a butterfly was not actively flying would not, alone, necessarily cause its descent.

Tomlinson (1973) discussed five means by which a butterfly might be raised to high altitude. These included convective cloud, thermals, initial lift provided by passage of a cold front, a small 'dust devil' equivalent to a small 'tornado' and the processes of turbulent transfer. When considering the April

1971 *Hypolimnas bolina* immigration into New Zealand, he estimated that temperatures at 1000 metres were from 7-10°C and at 3000 metres they were from -3-0°C. Even if conditions are not cold enough to induce torpor, the wind speeds at high altitudes could carry a flying or gliding butterfly from Australia to New Zealand in a matter of hours providing the specimen remained airborne, something which would not require much action on the part of the insect. It must be remembered that no damage is incurred by an insect which is simply supported by a moving body of air, irrespective of the speed at which the air mass is moving. Nine hours of flying time in a day is not exceptional for a migrant over land in eastern Australia.

Observations of arrivals in New Zealand, Lord Howe Island or Norfolk Island have, of course, all been made at ground level. The assertion is sometimes made that, as arrivals have only been recorded near ground level, high level arrival does not take place. This is an assumption which is difficult to accept when little opportunity has been available to make observations at high levels. A few authors (*e.g.* Johnson 1969, Smithers 1969, Tomlinson 1973, Holloway 1977) accepted that wind assisted high level travel could be involved in over sea migrations. Such assistance could allow long distances to be covered very quickly, considering that the winds at high altitudes are often very strong, persistent and maintain their direction for long periods. On the other hand, caution in accepting this has been justifiable in view of the lack of direct, positive, observational evidence.

Two instances of direct evidence that butterflies can rise to high altitudes and thereby have the opportunity to enter high level air streams are available. Both have involved 'thermals' as the lifting force. The first, from an unexpected source not likely to be noticed by entomologists (Welch and Welch 1965), originates in an observation made in August 1931 in Germany by W. Hirth, a German pioneer glider pilot. The first to make serious use of thermals at a time when the art of 'soaring' was in its infancy and gliders were slow-moving, Hirth (1938) wrote: 'I was unable to find any new up-currents in my immediate vicinity. However, I suddenly caught sight of some butterflies which had obviously reached that height under thermal influences and I hastened to make use of the same locality.' The observation was made at a height of 2000 ft.

The second observation was made by G. Sutherland (pers. comm.) while paragliding. Paragliders rely on thermals to obtain lift. Thermals frequently carry up debris such as leaves, grass, seeds and other parts of plants. These items are used by the flyers to detect thermals which, unless associated with cloud formations or other visible signs, cannot be detected. Butterflies were encountered (probably *B. java teutonia*) above 6000 ft; they were circling or flying 'aimlessly' in a thermal at Manilla, New South Wales, at the end of November 1997 and it is probable that most of them would have reached altitudes of 10,000 ft if they remained in the thermal. It is significant that low level migrations of *B. java teutonia* were recorded at several New South Wales localities before and at the same time as the observations in the thermals. These were at Ryde on 1.x.1997 (J.V. Peters), Turramurra on 7.xi.1997 (C.N. Smithers), Wallis Lake on 11-12.xi.1997 (A.B. Rose), Forster on 15.xi.1997 (A.B. Rose) and between Sydney and Goulburn on 27-28.xi.1997 (A.S. and C.N. Smithers). The last-mentioned was a continuous, sometimes dense migration observed over a distance of 100 km. Although there are no direct records of migration at ground level at Manilla itself at the time of the observation in the thermal, it is obvious from the localities and dates of the recorded migrations that there would almost certainly have been movements in the Manilla district, or nearby, at the time.

Rising with the aid of a thermal is one way which would provide access to a very strong and persistent high altitude wind system. Whether butterflies actively fly upwards once within a thermal or are passively lifted within the thermal is of little importance in the present context. In the case of winds travelling from Australia over the Pacific, butterflies could be moved consistently at speeds well in excess of 100 km/hour above 10,000 ft (*c.f.* Holloway 1977, p. 158, fig. 111 and associated discussion) and greater speeds at higher altitudes. This would enable a butterfly to complete the journey from Australia to Norfolk Island in a matter of hours, depending on the wind speed. It is relevant to note that all species of butterflies which have been recorded as arrivals in New Zealand and Norfolk Island are habitual migrants in Australia. They all cease flight at night and take nectar during their migrations over land. This is not possible when flying over sea but would not be necessary if their journey were fast enough and economical enough in energy consumption.

There are, of course, many records of migrating butterflies being seen at sea at low altitudes. *Tirumala hamata* was seen on 7 April 1995, two days before appearing on both Norfolk Island and New Zealand on 9 April 1995 (Smithers 1995, Early *et al.* 1995). This observation does not preclude the possibility of successful high altitude travel at the same time by parts of the same migrating population. It would depend on the conditions in the area of origin in Australia, which could be very extensive and variable. There is, also, no reason to assume that only one method is 'used' by the butterflies. It does seem, however, with the physiological constraints discussed by Johnson (1969), that fast-moving, long-distance, high level migrating individuals have an advantage and a better chance of successful long distance travel than low-level travellers moving 'under their own steam' across areas where 'refuelling' is not possible. There are many records of individual butterflies and other insects, some of which are small and possessed of very limited energy reserves, having been seen hundreds of miles from land. The turbulence caused by wind changing directions (as in the case of moths arriving on Norfolk Island (Holloway 1977), mentioned below) could well bring down high altitude butterflies before landfall, with the butterflies making only the final part of the journey at lower altitudes. This would be more likely in the case of New Zealand, where the land mass is much greater than that of Norfolk Island. Whether one or two 'methods' are available for successful long-distance movement will only become known through further observation. In any event, it must be accepted that there will probably be great losses of individuals on any long distance migration low over the sea through physiological failure. Movement within a high level air mass would not require exceptional energy expenditure; as long as the insect remains airborne it could be transported at high speed. A torpid butterfly could be carried for long distances, just as inanimate objects raised by bushfires are carried. Higher level movement is likely to be more economical than low level flight in terms of energy expenditure.

Holloway's (1977, p. 152) data indicated that for Norfolk Island 'Apart from October 1971, when conditions may have been exceptional, rarely does a peak of vagrant arrivals coincide with a period of strong and predominant westerlies.' Such peaks occurred when wind was 'changing from westerly to south-easterly or vice versa' and the moths themselves were taken more frequently in the traps on the eastern side of the island than the west. This suggests an approach from the east into sheltered areas of the island against the predominant westerly wind. The presence of the island near such wind conditions would 'create conditions favouring downfall on Norfolk as distinct from vagrant transport over Norfolk'. As the moths are Australian species they must, however, have originated in Australia. This apparent anomaly can be explained if the moths are using a high level route provided by the almost constant westerly winds which blow at high altitudes, irrespective of the low level wind directions at the time, and are brought down by the turbulence associated with wind direction change at low levels. At low level the winds were easterly and hence the moths were being assisted by easterly winds for the last part of the journey and approached the island from the east. Descent initiated by a zone of turbulence, whether cause by wind change or by presence of a land mass, need not be injurious to the insect.

It may require a different set of circumstances to occur for nocturnal insects, *e.g.* moths, to be lifted initially by thermals, which are essentially diurnal phenomena. Nocturnal migrants could well gain the required initial lift by some other mechanism, such as the 'cold front' method described by Tomlinson (1973). In the past, the hypothesis that butterflies (and other insects) can reach the heights necessary to enable them to be transported rapidly from Australia to New Zealand, Lord Howe and Norfolk Islands (Smithers 1969, Holloway 1977) has rested on somewhat circumstantial evidence. The two observations reported here lend strong, direct observational support to that hypothesis.

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